THE TOPOGRAPHICAL ANALYSIS CONCERNING THE VERTICAL MOVEMENT OF A ROAD BRIDGE UNDER LOAD

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Abstract. The vast majority of our country's road bridges were built at least three decades ago, faults and alterations being produced over time. To operate safely it is necessary to determine the degree of stability and the precautions needed. This paper presents the analysis of vertical movements for such an bridge, determined by topographic methods in order to establish the proper conditions under which it can be further exploited.

Keywords: Vertical movements, topographic methods

INTRODUCTION

Using a road bridge for merchandise and pedestrian traffic should flow under complete security conditions. When the bridge is located in a human settlement, the tracking of the conditions under which the traffic moves is all the more necessary.

This paper presents measurements made on a bridge with the length of 17,5m and the width of 6.5 m, located in the center of a town. The bridge was built with reinforced monolith concrete consisting of two abutments and a pile that supports four beams of reinforced monolith concrete, and over them a reinforced monolith concrete plaque is installed, and over it the asphalt was poured [4] (Fig. 1.).

The bridge was built in the seventh decade of the twentieth century, degradation appearing over time. Thus, facing the prop on the right bank, the armour is partly uncoated; also there is some segregation of the concrete in some parts, vegetation has appeared on the concrete elements [4].

Fig. 1. Sadu road bridge

Using the results for vertical movements, a topographically oriented behavioural analysis (for the road bridge during the observing process under static loads) is presented.

MATERIAL AND METHOD

To determine the values of the vertical movements, method the geometric precision leveling method was used, the observations were made with a precision instrument using stages with invar tape.

As a leveling point, the landmark located near the bridge was used (Fig. 2.), the control trademarks were materialized from concrete nails embedded in the bridge (Fig. 3.).

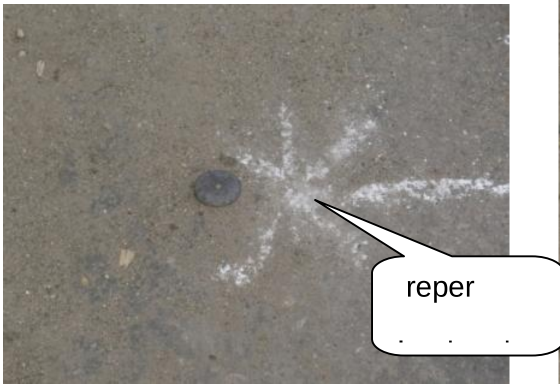


Fig. 2. Reper de nivelment
Leveling landmark

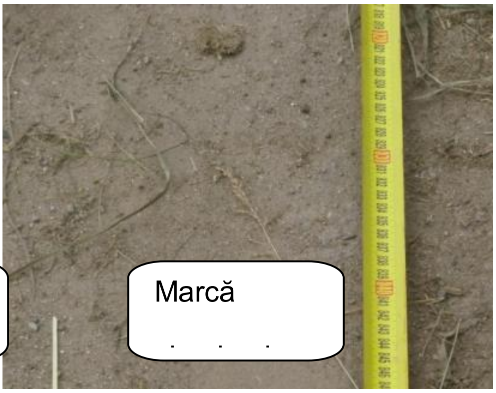


Fig. 3. Marcă de control
Checkpoint

The field layout in relation to the bridge, the leveling landmark and the check marks are shown in Fig. 4.

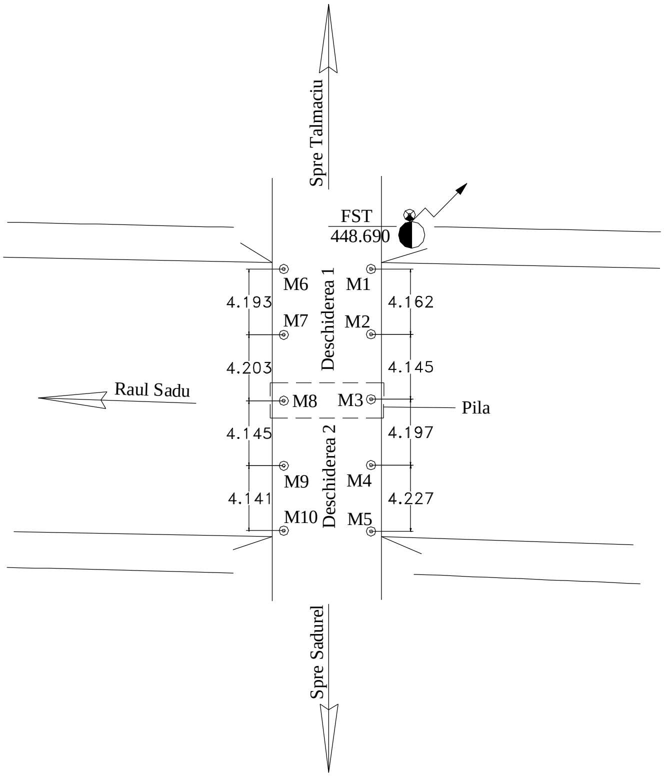


Fig. 4. The field layout of the landmark and the check marks

For the so constituted network, observations were carried out in three distinct phases:

I. without a load
II. with a 30t load on the first abutment
III. with a 30t load on the second abutment

The measurement conditions, the observation method and the instruments used for it were the same in all three stages.

RESULTS AND DISCUSSION

For addressing the processing method of the observations, the form and terms of the monitoring network realization were taken into consideration [1], following the purpose for which the observations were made, using the Solver module attached to *Microsoft Excel* [2], [5].

Table 1

SUBSIDENCE ESTABLISHING WORKSHEET								
Subject: The bridge over Sadu river, DJ 105G km 20+500, Sadu locality, Sibiu county								
Recipient: Sibiu County Council								
Measurement date: 04.06.2014					Reference landmark: FST = + 448.69000			
Nr. crt.	Name Landmark or point	Measurement without a load	The first static measurement – with a load on the first abutment			The second static measurement – with a load on the second abutment		
		04.06.2014	04.06.2014			04.06.2014		
		The level concerning the reference landmark	The level concerning the reference landmark	The subsidence regarding the measurement		The level concerning the reference landmark	The subsidence regarding the measurement	
		[m]	[m]	without a load [mm]		[m]	without a load [mm]	first static [mm]
0	1	2	3	4	5	6	7	8
1	FST-referinta. reference	448.69000	448.69000	0		448.69000	0	0
2	M1 – reazem support	448.68286	448.68333	0.47		448.68329	0.43	-0.04
3	M6 - reazem	448.71219	448.71197	-0.22		448.71221	0.02	0.24
4	M2 – deschidere opening	448.71986	448.71940	-0.46		448.71948	-0.38	0.08
5	M7 - deschidere	448.75542	448.75490	-0.52		448.75542	0	0.52
6	M3 - reazem	448.76292	448.76203	-0.89		448.76212	-0.8	0.09

7	M8 - reazem	448.78786	448.78767	-0.19		448.78793	0.07	0.26
8	M4 - deschidere	448.81705	448.81676	-0.29		448.81661	-0.44	-0.15
9	M9 - deschidere	448.83165	448.83154	-0.11		448.83139	-0.26	-0.15
10	M5 - reazem	448.85512	448.85404	-1.08		448.85361	-1.51	-0.43
11	M10 - reazem	448.87766	448.87766	0		448.87775	0.09	0.09

Table 2

DISTANCES BETWEEN THE SUBSIDENCE FOLLOW-UP MARKS								
The east side					The west side			
Nr. crt	The marks between which the distance was measured	The distance [m]			Nr. crt	The marks between which the distance was measured	The distance [m]	
1	M1-M2	4.162			1	M6-M7	4.193	
2	M2-M3	4.145			2	M7-M8	4.203	
3	M3-M4	4.197			3	M8-M9	4.145	
4	M4-M5	4.227			4	M9-M10	4.141	

The input data are represented by the level differences measured for each of the three stages.

After settling the limitations and selecting the condition of minimum size subject to improvement, $[vv]$, while activating the execution command, the compensated value of the level for each check mark (and through each of the three stages) was determined.

Vertical movements were determined as follows:

- for the static load on the first abutment, regarding the phase without a load;
- for the static load on the second abutment, regarding the phase without a load and the phase with a static load on the first abutment.

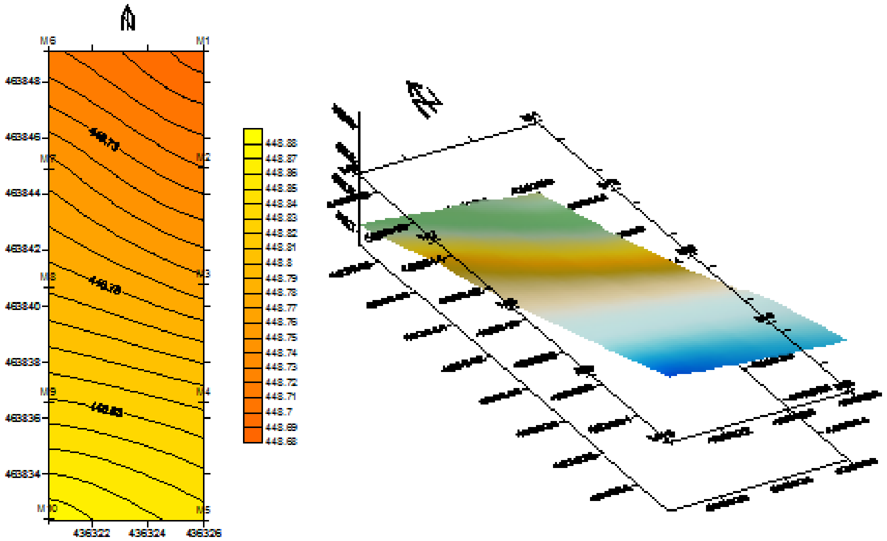
The values concluded from the calculations are shown in Table 1, and in Table 2 there are the values for the distances between the check marks on each side of the bridge.

Using the data obtained like so, the representation with leveling curves and the 3D model for the “no load” phase were made (Fig. 5.) the representation with equal subsidence curves and the 3D model for the “static load on the first abutment” phase (Fig. 6.) and also for the “static load on the second abutment” phase(Fig. 7., Fig. 8.)

In order for the representations to be as significant as possible, they were made like so:

- without charge (load) phase: the equidistance of the level curves (Fig. 5. a.) of 0.01 m and the scale for the 3D model’s level axis (Fig. 5. b.) is 20 times greater than the scale for the planimetric coordinates x , y;
- static charge on the first abutment phase: the equidistance for the equal subsidence curves (regarding the phase without charge) in Fig. 6. a. of 0.1mm, while the scale for the vertical movements of the 3D model (Fig. 6. b.) is 2500 times greater than the scale for the planimetric coordinates x, y;
- static charge on the second abutment phase: the equidistance for the equal subsidence curves (regarding to the phase without charge) in Fig. 7. a. of 0.1mm, while the scale for

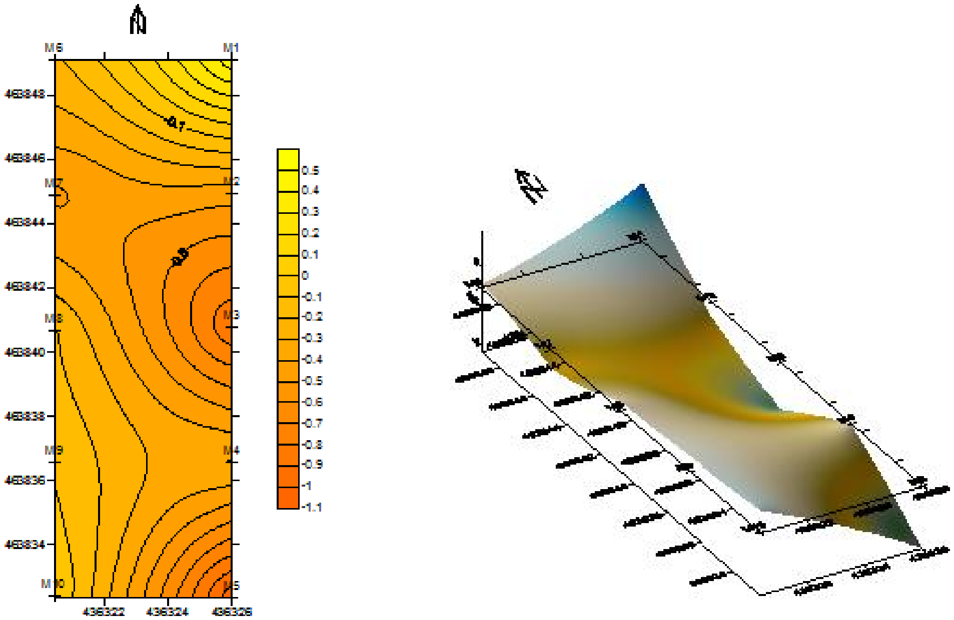
the vertical movements of the 3D model (Fig. 7. b.) is 2000 times greater than the scale for the planimetric coordinates x, y;



a. Leveling curves represantation b. 3D model

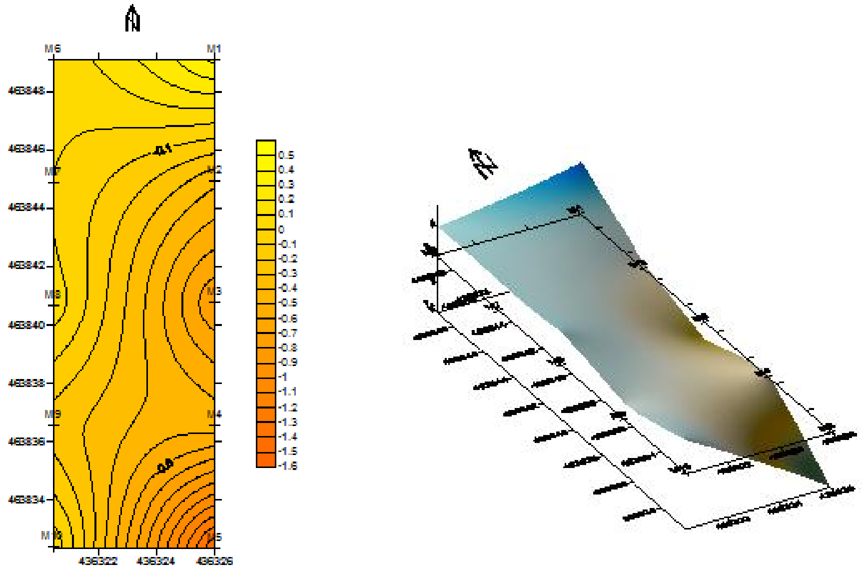
Fig. 5. The phase without a load

- static charge on the second abutment phase: the equidistance for the equal subsidence curves (regarding the static load on the first abutment phase) in Fig. 8. a. of 0.05 mm, and the scale for the vertical movements of the 3D model (Fig. 8. b.) is 4000 times greater than the scale for the planimetric coordinates x, y.



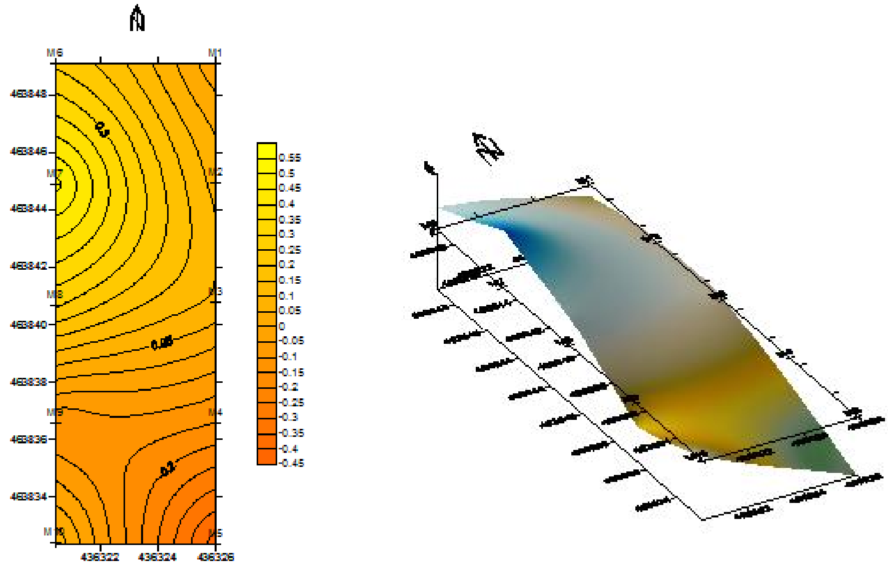
a. Leveling curves represantation b. 3D model

Fig. 6. The phase with a static load on the first abutment



a. Leveling curves represantation b. 3D model

Fig. 7. The phase with a static load on the second abutment - regarding phase I



a. Leveling curves represantation b. 3D model

Fig. 8. The phase with a static load on the second abutment - regarding phase II

Studying the graphic representations we realize the following:

- at the site, the longitudinal tilting direction of the bridge is N (Fig. 5.);

- during the test with a static load on the first abutment, the largest settlement on the abutment was registered by the mark M3 (located above the pile) and by the marks M2, M7 (located on the sides, at the middle of the opening); the value registered by M3 is justified by the fact that the front spindle of the 30t truck was facing the mark, and also by the condition in which the pile of the bridge was in;

- during the test with a static load on the second abutment, the largest settlement on the abutment was registered by the mark M3 (located above the pile) and by the marks M4, M9 (located on the sides, at the middle of the opening);

- the maximum values for the subsidence, in both static load phases, were registered by the mark M5, because the asphalt in the entire area where it was located was degraded.

The analysis of the data obtained from the static load test showed that the measured movements are lower than the limits set by technical regulations. Thus the maximum arrow measured has the value f_m = 0,52mm, while the maximum accepted arrow, determined according to the length of the opening is f_a = 9,06mm.

At the same time it was found that the remaining movements are negligible, and there were no signs of loss in functionality and stability of the bridge.

After the test with a static load, the bridge was subject to a test with sample dynamic actions, measuring the vibrations under the sample vehicle’s action; an experimental modal analysis, using an impact hammer, was also realized [4].

In the interpretation of the obtained data was found that the bridge is functional according to the class for which it was designed, however, to comply with current rules of classification it is imposed a superstructure widening from 6,50m to two lanes of 3,50m and a comfort optical space of 2x40cm, adding also two sidewalks with a minimum width of 1m with safety fences to separate it from the road; at the same time work is needed to strengthen the infrastructure, given the fact that the foundations are submerged under water and the elevations present degrading in masonry [4]. Another alternative, for placing the structure in the appropriate current class, is eliminating the pile, strengthening the abutments and replacing the superstructure [4].

CONCLUSIONS

The increasing necessity in construction supervision, both civil and engineering, but especially special constructions and works of art, given the lengthy exploitation period, requires the choice of methods and adequate technical solutions, and also an interdisciplinary approach to enable the assimilation of effective solutions regarding the functionality of the analyzed objectives.

Although regulated in terms of legislative matters, the supervising activity is “accessed” (in most cases) not for prevention, but for only when the events that compromise the safe usage, stability and durability have already happened.

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